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# The Journal of Bone & Joint Surgery

## Does surgical approach influence the outcomes following total hip arthroplasty performed for displaced intracapsular hip fractures? An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man --Manuscript Draft--

<b>Manuscript Number:</b>	JBJS-D-19-00195R2
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<b>Question</b>	<b>Response</b>
Is this a clinical trial? This is defined as any clinical research in which patients were randomized into two treatment groups OR in which patients were followed prospectively to compare two different treatments.	No
Was this study NIH funded?	No

Have any of the illustrations or tables used in this article been published previously (i.e. does another party now own the copyright to any illustration or table)?	No
Has this work been published previously on a preprint server? This is generally considered any online repository where the paper is made freely available before submission to a peer-reviewed journal.	No
How will this work influence the practice of Orthopaedics?	In the largest study involving THAs performed for hip fracture, we found that the posterior approach was safer than the anterolateral approach when performing THA for hip fractures, and should be preferred where possible. The findings have clear implications for clinical practice worldwide given the large, and predicted increase in, numbers of THA performed for hip fracture.
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<b>Abstract:</b>	<p><b>Background</b></p> <p>Studies suggest the anterolateral approach is preferable to the posterior approach when performing total hip arthroplasty (THA) for displaced intracapsular hip fractures, due to a perceived reduced risk of reoperations and dislocations. However, this comes from small studies with short follow-up. We determined whether surgical approach in THAs performed for hip fracture effects revision-free survival, patient survival, and intraoperative complications.</p> <p><b>Methods</b></p> <p>We retrospectively analysed all primary THAs for hip fractures between 2003-2015 recorded in the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. The two surgical approach groups (posterior versus anterolateral) were matched for patient and surgical confounding factors using propensity scores, with outcomes compared using regression modelling. Outcomes were 5-year revision-free survival (all-cause, revision for dislocation/subluxation, revision for periprosthetic fracture), patient survival (30-days, 1-year, and 5-years), and intraoperative complications.</p> <p><b>Results</b></p> <p>After matching, 14,536 THAs were studied (7,268 in each group). Five-year cumulative revision-free survival rates were similar (posterior 97.3% vs. anterolateral 97.4%; sub-hazard ratio (SHR) 1.15 (95% CI 0.93-1.42)). Five-year revision-free survival rates from dislocation (SHR=1.28 (CI=0.89-1.84)) and from revision for periprosthetic fracture (SHR=1.03 (CI=0.68-1.56)) were also comparable. Thirty-day patient survival was significantly higher with a posterior approach (99.5% vs. 98.8%; hazard ratio (HR)=0.44 (CI=0.30-0.64)), persisting at 1-year (HR=0.73 (CI=0.64-0.84)) and 5-years (HR=0.87 (CI=0.81-0.94)). The posterior approach had a lower risk of intraoperative complications (odds ratio=0.59 (CI=0.45-0.78)).</p> <p><b>Conclusions</b></p> <p>In THA for hip fractures, the posterior approach had a similar risk of revision, a lower</p>

	risk of mortality and intraoperative complications compared with the anterolateral approach. We propose that the posterior approach is as safe as the anterolateral approach when performing THA for hip fractures, and either approach may be used according to surgeon preference.
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**Response to reviewer comments for JBJS-D-19-00195R1 “Does surgical approach influence the outcomes following total hip arthroplasty performed for displaced intracapsular hip fractures? An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man”**

We would like to thank the editor and the reviewer for their comments, which we feel have helped us to improve our paper.

Please note all changes to the main manuscript text have been highlighted in **bold text**.

Responses to editor and reviewers' comments are also in **bold text** below.

**Deputy Editor Comments**

Dear Mr. Matharu:

Thank you for revising your manuscript. The manuscript is much improved as a result of your revisions.

I have included a short comment from Reviewer #3 regarding your conclusion. I agree with Reviewer #3 that your conclusion is too strong for the data that you have presented – I don't think you can state with such certainty that one approach is superior to another. I would ask that you modify the comments that you have made in your conclusion to reflect that all approaches largely speaking are safe and you cannot reliably recommend one over the other. Please consider these comments and, if you feel that they can be addressed in a major revision of the manuscript, please submit your revised manuscript along with a response letter that contains a point-by-point response to the comments. Additionally, all corresponding changes to the text should be in bold. The due date for revision will be Aug 02 2019 11:59PM.

**In light of the editor and reviewer comments we have altered our conclusion of the abstract (2<sup>nd</sup> sentence) and the conclusion of the main text accordingly (2<sup>nd</sup> sentence).**

When I get your revised manuscript back with those changes we will send it to the Methodology & Statistics Editor for a final assessment.

Yours truly,  
James P. Waddell, C.M., MD, FRCSC  
Deputy Editor

The Journal of Bone & Joint Surgery

Reviewer 3:

Conclusion slightly too rigid as to "preference" and "should". Possibly preference is okay but working at "should" -is a sweeping generalization a problem in light of other literature. Editor to decide.

**We have altered our conclusion of the abstract (2<sup>nd</sup> sentence) and the conclusion of the main text accordingly (2<sup>nd</sup> sentence).**

**Does surgical approach influence the outcomes following total hip arthroplasty performed for displaced intracapsular hip fractures? An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man**

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# **Does surgical approach influence the outcomes following total hip arthroplasty performed for displaced intracapsular hip fractures? An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man**

## **Abstract**

### **Background**

Studies suggest the anterolateral approach is preferable to the posterior approach when performing total hip arthroplasty (THA) for displaced intracapsular hip fractures, due to a perceived reduced risk of reoperations and dislocations. However, **this** comes from small studies with short follow-up. We determined whether surgical approach in THAs performed for hip fracture effects **revision-free** survival, patient survival, and intraoperative complications.

### **Methods**

We retrospectively analysed all primary THAs for hip fractures between 2003-2015 recorded in the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. The two surgical approach groups (posterior versus anterolateral) were matched for patient and surgical confounding factors using propensity scores, with outcomes compared using regression modelling. Outcomes were **5-year revision-free** survival (all-cause, revision for dislocation/subluxation, revision for periprosthetic fracture), patient survival (30-days, 1-year, and 5-years), and intraoperative complications.

## Results

After matching, 14,536 THAs were studied (7,268 in each group). **Five-year cumulative revision-free** survival rates were similar (posterior 97.3% vs. anterolateral 97.4%; sub-hazard ratio (SHR) 1.15 (95% CI 0.93-1.42)). Five-year **revision-free** survival rates from dislocation (SHR=1.28 (CI=0.89-1.84)) and from revision for periprosthetic fracture (SHR=1.03 (CI=0.68-1.56)) were also comparable. Thirty-day patient survival was significantly higher with a posterior approach (99.5% vs. 98.8%; hazard ratio (HR)=0.44 (CI=0.30-0.64)), **persisting** at 1-year (HR=0.73 (CI=0.64-0.84)) and 5-years (HR=0.87 (CI=0.81-0.94)). The posterior approach had a **lower** risk of intraoperative complications (odds ratio=0.59 (CI=0.45-0.78)).

## Conclusions

In THA for hip fractures, the posterior approach had a similar risk of revision, a lower risk of mortality and intraoperative complications compared with the anterolateral approach. We propose that the posterior approach is **as safe as the** anterolateral approach when performing THA for hip fractures, and **either approach may be used according to surgeon preference**.

## Level of Evidence

Prognostic Level III



## Introduction

Hip fractures are common in elderly patients ( $\geq 60$  years), and associated with significant mortality, morbidity, and healthcare costs.<sup>1, 2</sup> In the **US**, over 300,000 hip fractures occur annually,<sup>3</sup> **with increasing** incidence.<sup>4</sup> Displaced intracapsular hip fractures are the commonest type (48%),<sup>5</sup> **and are** treated using hemiarthroplasty or total hip arthroplasty (THA). THA **has** lower reoperation rates and improved functional outcomes.<sup>6-9</sup> The National Institute for Health and Care Excellence recommends that for displaced intracapsular hip fractures, THA should be performed in independently mobile patients with no cognitive impairment who are medically fit for anaesthesia/surgery.<sup>2</sup> **However**, a recent analysis of the **UK** National Hip Fracture Database (NHFD) involving 114,119 hip fractures reported only 32% of eligible patients received THA.<sup>10</sup> Strategies have now been implemented to improve this;<sup>2</sup> therefore we expect the number of THAs for hip fractures will increase.

Two main surgical approaches are used for THA, posterior or anterolateral. In the elective setting, there is no conclusive evidence to recommend one approach over the other in terms of reoperation rates or functional outcomes,<sup>11-14</sup> although the posterior approach has been associated with lower 90-day mortality.<sup>15</sup> Surgeons therefore decide which approach to use, largely dictated by training and preference. Few studies have assessed the effect of approach on outcomes following THA for hip fracture. **Current** data suggests the anterolateral approach is preferable as it is associated with a reduced risk of reoperations and dislocations.<sup>16-21</sup> However, these studies **were** small (171-1,412 THAs) with short-term follow-up (3-24 months).

We assessed the effect of surgical approach on outcomes following THA performed for hip fractures.

## Methods

A retrospective analysis of prospectively collected observational data was performed using data from the National Joint Registry (NJR) for England, Wales, Northern Ireland and the Isle of Man. It was established in April 2003 and is the world's largest arthroplasty registry.<sup>22</sup>

**Preoperatively** patients consent for their details to be recorded within the NJR and data linkage to be performed, with 92% providing consent.<sup>22</sup> **In the emergency setting, such as hip fracture, consent is taken whilst the patient rehabilitates in hospital.** Operating teams complete data capture forms after performing primary or revision arthroplasty, which are entered onto the database.

Independent validation studies have reported data completion and accuracy are excellent for primary and revision procedures within the NJR.<sup>23, 24</sup> Unique patient identifiers permit linkage of primary and revision procedures where components are removed, added or exchanged. The NJR achieves high levels of procedure linkage (94%).<sup>22</sup> The NJR database was linked **to** the Office for National Statistics (ONS) database (**records** all-cause mortality).

**We used** anonymized patient data from the NJR **for** stemmed primary THAs performed for hip fractures between 1<sup>st</sup> April 2003 and 31<sup>st</sup> December 2015 (n=18,887; Table 1), **which allowed at least 1-year of follow-up.** The exposure was the surgical approach for THA, namely posterior or anterolateral (anterolateral, lateral, and Hardinge). For each procedure the NJR collects data on patient demographics and the surgery performed. Data collected includes age, sex, body mass index (BMI), date of surgery, American Society of Anesthesiologists (ASA) grade, anesthetic, surgeon grade, and components implanted (fixation, bearing surface, femoral head size).

Outcomes of interest were **revision-free** survival (at 5-years), patient survival (at 30-days, 1-year and 5-years), and intraoperative complications (calcar crack, pelvic and/or femoral shaft penetration, trochanteric and/or femoral shaft fracture, and other complications). **Revision-free** survival was examined using three **survival** endpoints: free from all-cause revision (i.e. no THA component added, removed and/or exchanged), free from revision for dislocation/subluxation, and free from revision for periprosthetic fracture.

### **Statistical analysis**

We controlled for potential patient and surgical confounding factors using propensity score matching. Posterior approach THAs were matched by propensity scores to anterolateral approach THAs (one-to-one ratio).<sup>25, 26</sup> We matched on the logit of the propensity score with a 0.02 standard deviation caliper width. Greedy matching (match to nearest neighbor) without replacement was used (each hip matched only once), which has demonstrated superior performance for estimating treatment effects.<sup>25</sup>

Approach groups were matched for age, sex, year of surgery, bilateral THA for hip fracture, ASA grade, anesthetic, surgeon grade, THA fixation, bearing surface, and femoral head size. Groups were not matched on body mass index **because of missing data** (81% missing as difficult to measure in fracture patients).<sup>27</sup> Missing BMI data is a limitation of NJR based studies with previous work showing no effect on outcomes following imputation.<sup>15, 28, 29</sup>

Propensity scores were generated using logistic regression, with scores representing the probability (from zero to one) that a posterior approach was used. The two groups were matched based on individual propensity scores. The standardised mean difference (SMD) was

used to measure covariate imbalance before and after matching.<sup>30, 31</sup> An SMD of 0.10 or more for any covariate following matching was **suggestive** of residual covariate imbalance.<sup>25, 30</sup>

Cumulative **revision-free** and patient survival rates were determined using Kaplan-Meier estimates. Patients who were alive with a THA not requiring revision were censored on the study end date (31<sup>st</sup> December 2016). **Revision-free** survival rates were compared between approach groups using Fine and Gray competing risk regression modelling, which accounted for mortality risk. Patient survival rates were compared between the groups using Cox regression, **whilst** the risk of intraoperative complications was compared using logistic regression. Proportional sub-hazards and hazards assumptions were assessed and satisfied for all analyses. To account for clustering within the matched cohort, a robust variance estimator was used in the **revision-free** and patient survival regression models, with a conditional logistic regression model used for assessing intraoperative complications.<sup>32</sup> Univariable regression models were assessed in the matched cohort. As a sensitivity analysis, univariable regression models were also assessed in the original unmatched cohort. P-values of <0.05 were considered significant, with 95% confidence intervals (CI) also used.

### **Source of funding**

National Institute for Health Research Bristol Biomedical Research Centre, University Hospitals Bristol NHS Foundation Trust and University of Bristol.

## Results

In the unmatched cohort (n=18,887; Table 1) six covariates had imbalance between groups (SMDs $\geq$ 0.10). After matching there were 14,536 **cases** available for analysis (7,268 per group), **with** no covariate imbalance suggesting good **matching** performance (Table 1). All analyses are based on the matched cohort unless **stated**. The **mean** follow-up period for surviving patients not undergoing revision was 4.0-years (range 1.0-13.0), and similar between groups (mean 3.9-years posterior and 4.0-years anterolateral).

### Revision-free survival

Overall 350 THAs were revised at a mean postoperative time of 1.8 years (range 0 days to 12.1 years). The commonest reasons for revision were dislocation/subluxation (n=118; 33.7% of all revisions), periprosthetic fracture (n=84; 24.0%), aseptic loosening (n=55; 15.7%), and infection (n=53; 15.1%) (Table 2).

The 5-year cumulative **revision-free** survival rates were similar between the approach groups (posterior 97.3% vs. anterolateral 97.4%; sub-hazard ratio (SHR) 1.15 (CI 0.93-1.42); p=0.185) (Table 3 and Figure 1). The 5-year cumulative **revision-free** survival rates for dislocation were similar (98.9% vs. 99.2%; SHR 1.28 (CI 0.89-1.84); p=0.188). The 5-year cumulative **revision-free** survival rates for periprosthetic fracture were similar (99.4% vs. 99.4%; SHR 1.03 (CI 0.68-1.56); p=0.879).

### Patient survival

Overall there were 2,885 deaths at a mean of 2.8 years (range 0 days to 12.2 years) from surgery. Thirty-day cumulative patient survival rates were significantly higher in THAs implanted using a posterior approach (99.5% vs. 98.8%; hazard ratio (HR)=0.44 (CI=0.30-

0.64);  $p < 0.001$ ) (Table 3). These observations persisted at 1-year (HR=0.73 (CI=0.64-0.84);  $p < 0.001$ ) and 5-years (HR=0.87 (CI=0.81-0.94);  $p < 0.001$ ) (Table 3 and Figure 2).

### **Intraoperative complications**

Overall the risk of intraoperative complications was 1.5% (n=224). The commonest complications were fractures of the calcar (n=80; 36% of all intraoperative complications), trochanter (n=61; 27%) and pelvis (n=48; 21%). The risk of intraoperative complications **with** the posterior approach was 1.2% (n=84) compared with 1.9% (n=140) **with** the anterolateral approach. **The** posterior approach had a significantly **lower** risk of intraoperative complications (odds ratio=0.59 (CI=0.45-0.78);  $p < 0.001$ ).

### **Sensitivity analyses**

In the unmatched cohort, the same findings were observed as in the matched cohort for **revision-free** survival rates, **30-day** patient survival rates, and the risk of intraoperative complications (Appendix). However in the unmatched cohort, patient survival rates were similar between the approach groups at 1-year and 5-years **postoperatively**.

## Discussion

This is the largest study assessing the influence of surgical approach on outcomes following THA for hip fracture. We observed that the posterior approach was associated with a reduced risk of mortality and intraoperative complications compared with the anterolateral approach. The posterior approach did not confer any increased risk of revision surgery, including specifically for dislocation and periprosthetic fracture.

Our observations regarding similar revision rates between the two approach groups were seen in both the matched and unmatched cohorts. These findings were contrary to previous studies, which have suggested the anterolateral approach is associated with a reduced risk of reoperations and dislocations.<sup>16-21</sup> Some of these differences may relate to study design. Previous studies have been small (most with less than 1,000 THAs) with short-term follow-up and few outcome events. These previous analyses may have been underpowered for the outcomes assessed. Furthermore, previous studies have not matched the two approach groups for known risk factors for dislocation and fracture, such as age, sex, implant fixation and femoral head size.<sup>33, 34</sup> **For example in the unmatched cohort, larger femoral head sizes (above 36mm) were more commonly used in the posterior compared with the anterolateral approach (Table 1: 26.4% vs. 16.6%), which may reduce the risk of revision for dislocation. However after matching, the use of large heads were similar between groups (posterior 19.0% vs. anterolateral 18.5%).** Therefore the current matched analysis reduced the risk of confounding, which improves the validity of our findings in a large population based study.

The posterior approach is the most commonly used approach when elective THAs are performed for arthritis.<sup>22, 35</sup> The present unmatched cohort from the NJR **also** demonstrates

that it is the most frequently used approach for THAs performed for hip fracture in **this setting** (56.4%). It has been suggested that surgeons will achieve the best results following THAs for hip fracture if they use the approach with which they are most familiar.<sup>36</sup> Early observations from the NJR of 1,302 THAs performed for hip fracture found a higher revision rate with the posterior approach (3.5% vs. 1.3% at 3 years), which coincides with a time when the posterior approach was used less frequently for elective THA.<sup>20</sup> The increased use of the posterior approach for THA may also explain the reduced risk (41%) of intraoperative complications, namely fractures, observed.

Hip fracture surgery is associated with high mortality rates, which are much higher **than** elective THA.<sup>37</sup> The NHFD reported overall 30-day mortality rates in all hip fractures of 6.7%, with a secular decline.<sup>2</sup> We observed a much lower 30-day mortality rate for all THAs for hip fractures (0.9%), **reflecting** selection bias of medically fit and independently mobile patients for THA. Despite **this** low mortality rate, we still observed a significantly reduced risk (56%) of 30-day mortality when using the posterior compared with the anterolateral approach. In the matched cohort, this improved patient survivorship waned with time, but had not completely dissipated by 5-years postoperatively. Our analysis in the unmatched cohort confirmed a significantly reduced risk of 30-day mortality with the posterior approach; therefore supporting a real effect of surgical approach on mortality at least in the short-term. We are unaware of any **other** large studies assessing the effect of surgical approach on mortality following THA for hip fracture. A study of 409,096 elective THAs from the NJR demonstrated a significantly lower 90-day mortality rate in procedures performed using a posterior approach.<sup>15</sup> These observations parallel the current observations in hip fracture patients. The posterior approach is a more muscle sparing approach compared with the anterolateral approach **and associated with less bleeding**.<sup>38</sup> Problems therefore seen more



commonly following the anterolateral approach include nerve injury,<sup>38</sup> reduced muscle strength,<sup>39</sup> and limping.<sup>12</sup> These problems invariably influence patient mobility, especially in the early postoperative phase when the mortality risk will be high. **Our previous exploration of mortality in elective THA demonstrated lower all-cause and respiratory mortality with the posterior approach, most likely related to improved mobility, an effect likely to be more marked in a frail population.**<sup>40</sup> We therefore suspect these factors explain the lower mortality rates observed, especially in the short-term, when using the posterior approach.

Study strengths include using linked data from the world's largest arthroplasty registry. Assessment of an unselected nationwide population reduces the risk of sampling bias, **improving** validity and generalisability. Although randomised controlled trials would be ideal for assessing this research question, such trials would be impractical as huge patient numbers would be required to power the study given the prevalence of revision, mortality, and intraoperative complications were relatively low.<sup>41</sup> Therefore large cohort studies ensure adequate statistical power and reduce the risk of overfitting the regression models; thus this design is ideal for our proposed research question. Robust statistical methods were used in this study. **This included studying** a large matched **comparison** group, **thus reducing any effects from** other potential confounding factors.<sup>27</sup> Finally, studies validating NJR data have observed that, when procedures were captured within the NJR, the data completion and accuracy were excellent.<sup>23, 24</sup>

Recognised limitations include using observational data, so causality cannot be inferred. THA revision rates can be underestimated in the NJR,<sup>23, 24</sup> although there is no reason to suspect any underreporting would differ between the approach groups. **The NJR** does not

collect data on patient reported outcome measures (PROMs) **following hip fracture**, non-revision procedures (i.e. wound washouts, fixation of fractures, and closed reductions of dislocated hips), **or complications not requiring further surgery (i.e. conservatively treated dislocations, fractures, and infections)**, which are **all** important to consider when comparing approaches. **Therefore we cannot estimate the true incidence of dislocation, periprosthetic fracture, and infection after THA for hip fracture, only those undergoing revision.** Linkage has been possible for NJR and PROMs data for elective THA, which has favoured the posterior approach.<sup>42</sup>

Despite matching there is potential for residual confounding. **We could only match for covariates where data is collected and available in the NJR, so it is not possible to have matched for specific serious medical comorbidities (e.g. renal or cardiac failure), or conditions where patients may be at increased risk of THA dislocation (e.g. Parkinson's disease or cerebral palsy), which may have influenced approach selection and the findings.** However when significant findings were identified, the observed effect sizes were large; therefore it is unlikely any unmeasured factors would have been large enough to change the direction of the effect sizes. Matching may have also reduced the generalisability of the study findings, although similar findings were observed when the analyses were repeated in the original unmatched cohort. **In addition, our findings may not apply in countries using different techniques. For example about 70% of femoral stems were cemented in this study. Given cemented stems have a lower risk of fracture compared with cementless stems, our findings may not apply in regions performing predominantly cementless stem THA for hip fracture.**

Although the follow-up period was short (mean 4 years), the majority of complications attributable to surgical approach would be expected to occur in this period. Matching for BMI would have strengthened the findings, but due to low data completion for this variable **in hip fractures**, matching could not be undertaken. Reassuringly the available BMI data was similar between the two approach groups before and after matching. **The NJR does not collect data on the specific details of how each approach was performed. Therefore we are limited by not having data on parameters, which may influence the outcomes and study findings when considering surgical approach. These include what specific approach techniques were used (i.e. anterolateral approach has many variants), the repair performed (none, capsular, short external rotators, abductors, and whether repairs were soft-tissue or intraosseous), intraoperative blood loss, and surgical time. Furthermore it was not possible to explore the effect of the increasingly popular direct anterior approach in this study given low numbers and variable collection over the life of the NJR.**

## **Conclusions**

This large nationwide study observed that in patients undergoing THA for hip fracture, the posterior approach had a similar risk of revision surgery, a lower risk of mortality and intraoperative complications compared with the anterolateral approach. We therefore propose that the posterior approach is **as safe as the** anterolateral approach when performing THA for hip fractures, and **either approach may be used according to surgeon preference.**

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## Figure Legends

**Figure 1** Cumulative **revision-free** survival rate free from all-causes following primary total hip arthroplasty (THA) performed for hip fracture by surgical approach.

Shaded area represents the respective upper and lower limits of the 95% confidence interval (CI).

**Figure 2** Cumulative patient survival rate following primary total hip arthroplasty (THA) performed for hip fracture by surgical approach.

Shaded area represents the respective upper and lower limits of the 95% confidence interval (CI).

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## **Competing Interests**

We have read the journal's policy and the authors of this manuscript have the following competing interests: GSM has received financial support for other research work from Arthritis Research UK, The Orthopaedics Trust, The Royal College of Surgeons of England, and The Royal Orthopaedic Hospital Hip Research and Education Charitable Fund. GSM has also received personal fees for undertaking medicolegal work for Leigh Day. AJ has received consultancy, lecture fees and honoraria from Servier, UK Renal Registry, Oxford Craniofacial Unit, IDIAP Jordi Gol, Freshfields Bruckhaus Deringer, is a member of the Data Safety and Monitoring Board (which involved receipt of fees) from Anthera Pharmaceuticals, INC., and received consortium research grants from ROCHE. KW has no relevant conflicts. AWB has no relevant conflicts of interest. MRR has received grant funding or lecture fees from the Health Foundation, Stryker, Zimmer Biomet, Heraeus Medical, 3M healthcare, Vifor Pharma and Schuelke. MRW is a co-applicant on a grant funded by Stryker investigating the outcome of a total knee replacement manufactured by Stryker. MRW also carries out basic science teaching on behalf of Heraeus and DePuy for which his employer receives payment at market rates.

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**Table 1** Patient and surgical factors before and after propensity score matching

	Unmatched cohort				Matched cohort			
	All primary THAs (n=18,887) (100%)	Antero-lateral approach (n=8,226) (43.6%)	Posterior approach (n=10,661) (56.4%)	SMD	All primary THAs (n=14,536) (100%)	Antero-lateral approach (n=7,268) (50%)	Posterior approach (n=7,268) (50%)	SMD
<i>Covariate</i>								
<b>Sex</b> Female vs. male	13,844 (73.3)	6,093 (74.1)	7,751 (72.7)	0.031	10,734 (73.8)	5,357 (73.7)	5,377 (74.0)	0.006
<b>Age at primary (yr)</b> Mean (SD)	71.6 (10.0)	71.6 (9.8)	71.6 (10.2)	0.002	71.6 (10.0)	71.6 (9.9)	71.5 (10.1)	0.006
<b>BMI (kg/m<sup>2</sup>) *</b> Mean (SD)	26.0 (5.1)	26.2 (5.3)	25.8 (5.0)	0.069	25.9 (5.1)	26.2 (5.3)	25.7 (4.9)	0.099
<b>Bilateral hips</b>	421 (2.2)	178 (2.2)	243 (2.3)	0.008	325 (2.2)	163 (2.2)	162 (2.2)	0.001
<b>Primary year</b> 2003-2012 2013-2015	8,534 (45.2) 10,353 (54.8)	4,160 (50.6) 4,066 (49.4)	4,374 (41.0) 6,287 (59.0)	<b>0.192</b>	6,772 (46.6) 7,764 (53.4)	3,402 (46.8) 3,866 (53.2)	3,370 (46.4) 3,898 (53.6)	0.009
<b>Primary ASA grade</b> 1 2 3 or above	1,975 (10.5) 11,563 (61.2) 5,349 (28.3)	881 (10.7) 5,120 (62.2) 2,225 (27.1)	1,094 (10.3) 6,443 (60.4) 3,124 (29.3)	0.050	1,562 (10.8) 8,968 (61.7) 4,006 (27.6)	754 (10.4) 4,485 (61.7) 2,029 (27.9)	808 (11.1) 4,483 (61.7) 1,977 (27.2)	0.026
<b>Anesthetic</b> General Spinal Epidural Nerve block	10,187 (53.9) 9,818 (52.0) 985 (5.2) 2,507 (13.3)	4,154 (50.5) 4,328 (52.6) 461 (5.6) 1,011 (12.3)	6,033 (56.6) 5,490 (51.5) 524 (4.9) 1,496 (14.0)	<b>0.122</b> 0.022 0.031 0.052	7,652 (52.6) 7,491 (51.5) 764 (5.3) 1,857 (12.8)	3,845 (52.9) 3,738 (51.4) 386 (5.3) 945 (13.0)	3,807 (52.4) 3,753 (51.6) 378 (5.2) 912 (12.6)	0.010 0.004 0.005 0.014
<b>Surgeon grade</b> Consultant vs. other	13,933 (73.8)	5,622 (68.3)	8,311 (78.0)	<b>0.218</b>	10,617 (73.0)	5,326 (73.3)	5,291 (72.8)	0.011
<b>Fixation</b> Cemented Uncemented Hybrid Reverse hybrid	8,274 (43.8) 4,646 (24.6) 5,449 (28.9) 518 (2.7)	4,032 (49.0) 2,166 (26.3) 1,840 (22.4) 188 (2.3)	4,242 (39.8) 2,480 (23.3) 3,609 (33.9) 330 (3.1)	<b>0.271</b>	6,798 (46.8) 3,732 (25.7) 3,620 (24.9) 386 (2.7)	3,415 (47.0) 1,869 (25.7) 1,800 (24.8) 184 (2.5)	3,383 (46.6) 1,863 (25.6) 1,820 (25.0) 202 (2.8)	0.014
<b>Femoral head size</b> Under 32 mm 32mm 36 mm and above	8,551 (45.3) 6,155 (32.6) 4,181 (22.1)	4,273 (52.0) 2,591 (31.5) 1,362 (16.6)	4,278 (40.1) 3,564 (33.4) 2,819 (26.4)	<b>0.280</b>	6,977 (48.0) 4,834 (33.3) 2,725 (18.8)	3,499 (48.1) 2,427 (33.4) 1,342 (18.5)	3,478 (47.9) 2,407 (33.1) 1,383 (19.0)	0.014
<b>Bearing surface</b> MoP CoP CoC MoM	14,851 (78.6) 2,206 (11.7) 1,282 (6.8) 548 (2.9)	6,699 (81.4) 757 (9.2) 547 (6.7) 223 (2.7)	8,152 (76.5) 1,449 (13.6) 735 (6.9) 325 (3.1)	<b>0.144</b>	11,664 (80.2) 1,450 (10.0) 1,010 (7.0) 412 (2.8)	5,830 (80.2) 726 (10.0) 502 (6.9) 210 (2.9)	5,834 (80.3) 724 (10.0) 508 (7.0) 202 (2.8)	0.007

ASA = American Society of Anesthesiologists; BMI = body mass index; CoC = ceramic-on-ceramic; CoP = ceramic-on-polyethylene; MoM = metal-on-metal; MoP = metal-on-polyethylene; SD = standard deviation; SMD = standardised mean difference; THA = total hip arthroplasty

Values in brackets are percentages unless otherwise indicated.

\* Missing data for stated number of hips: BMI (n=15,288 in unmatched cohort, and n=11,783 in matched cohort).

Standardised mean differences of 0.10 or more have been highlighted in bold text



**Table 2** Indications for 350 all-cause revision procedures following primary total hip arthroplasty performed for hip fractures

Indication for revision surgery	Number of revised hips with indication (% of all revisions)
Dislocation / subluxation	118 (33.7)
Periprosthetic fracture	84 (24.0)
Aseptic loosening	55 (15.7)
Infection	53 (15.1)
Malalignment	36 (10.3)
Pain	25 (7.1)
Implant wear	19 (5.4)
Adverse soft tissue reaction to particulate debris	15 (4.3)
Other	13 (3.7)
Lysis	4 (1.1)
Implant fracture	3 (0.9)
Head socket mismatch	2 (0.6)

One or more indications may be selected for each hip undergoing revision.

A number of the revision indications (aseptic loosening; implant malalignment; periprosthetic fracture; lysis; implant fracture) can include a problem on either the femoral side or the acetabular side or both sides.



**Table 3** Outcomes following primary total hip arthroplasty performed for hip fractures by surgical approach in the matched cohort

	<b>Whole matched cohort (n=14,536; 100%)</b>	<b>Anterolateral approach (n=7,268; 50%)</b>	<b>Posterior approach (n=7,268; 50%)</b>	<b>Univariable regression analysis</b>
5 year implant survival rate free from all-causes (350 revisions)	97.3% (97.0-97.6)	97.4% (96.9-97.8)	97.3% (96.8-97.7)	SHR = 1.15 (0.93-1.42)  p=0.185
5 year implant survival rate free from dislocation or subluxation (118 revisions)	99.0% (98.8-99.2)	99.2% (98.9-99.4)	98.9% (98.6-99.2)	SHR = 1.28 (0.89-1.84)  p=0.188
5 year implant survival rate free from periprosthetic fracture (84 revisions)	99.4% (99.2-99.5)	99.4% (99.1-99.6)	99.4% (99.1-99.6)	SHR = 1.03 (0.68-1.56)  p=0.879
30 day patient survival (131 deaths)	99.1% (99.0-99.3)	98.8% (98.5-99.0)	99.5% (99.3-99.6)	HR = 0.44 (0.30-0.64)  p < 0.001
1 year patient	94.1%	93.3%	95.0%	HR = 0.73

survival (857 deaths)	(93.7-94.5)	(92.7-93.8)	(94.5-95.5)	(0.64-0.84)  p < 0.001
5 year patient survival (2,321 deaths)	78.0% (77.1-78.9)	76.8% (75.6-78.0)	79.2% (77.9-80.4)	HR = 0.87 (0.81-0.94)  p < 0.001
Intraoperative complications (224 complications)	1.5% (n=224)	1.9% (n=140)	1.2% (n=84)	OR = 0.59 (0.45-0.78)  p < 0.001

HR = hazard ratio; OR = odds ratio; SHR = sub-hazard ratio

Numbers in brackets represent the 95% confidence intervals.

Hazard, odds, and sub-hazard ratios below 1 represent a reduced risk of the specified outcome in the posterior approach group.

Figure 1

# THA Implant survival free from all causes at up to 5-years

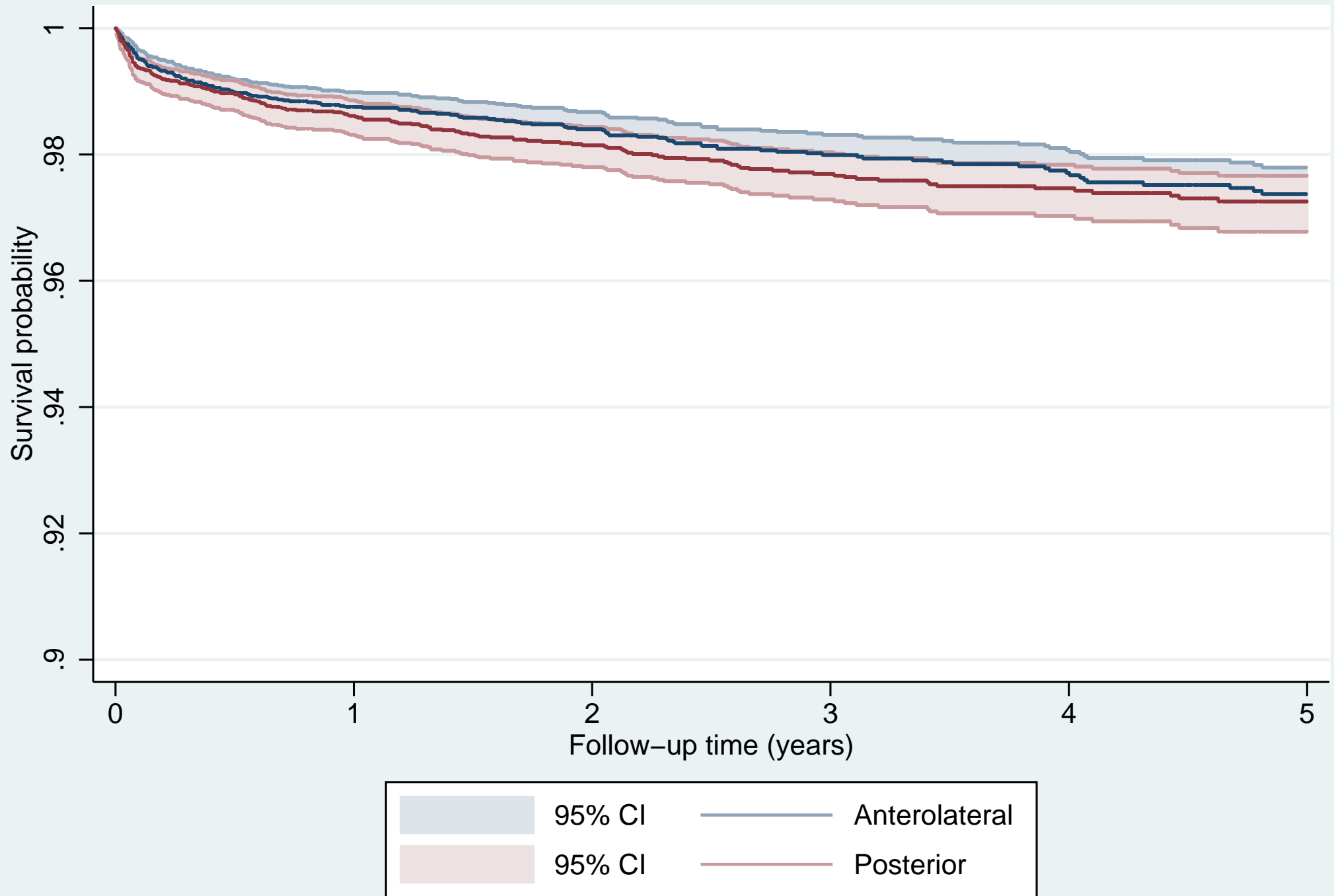
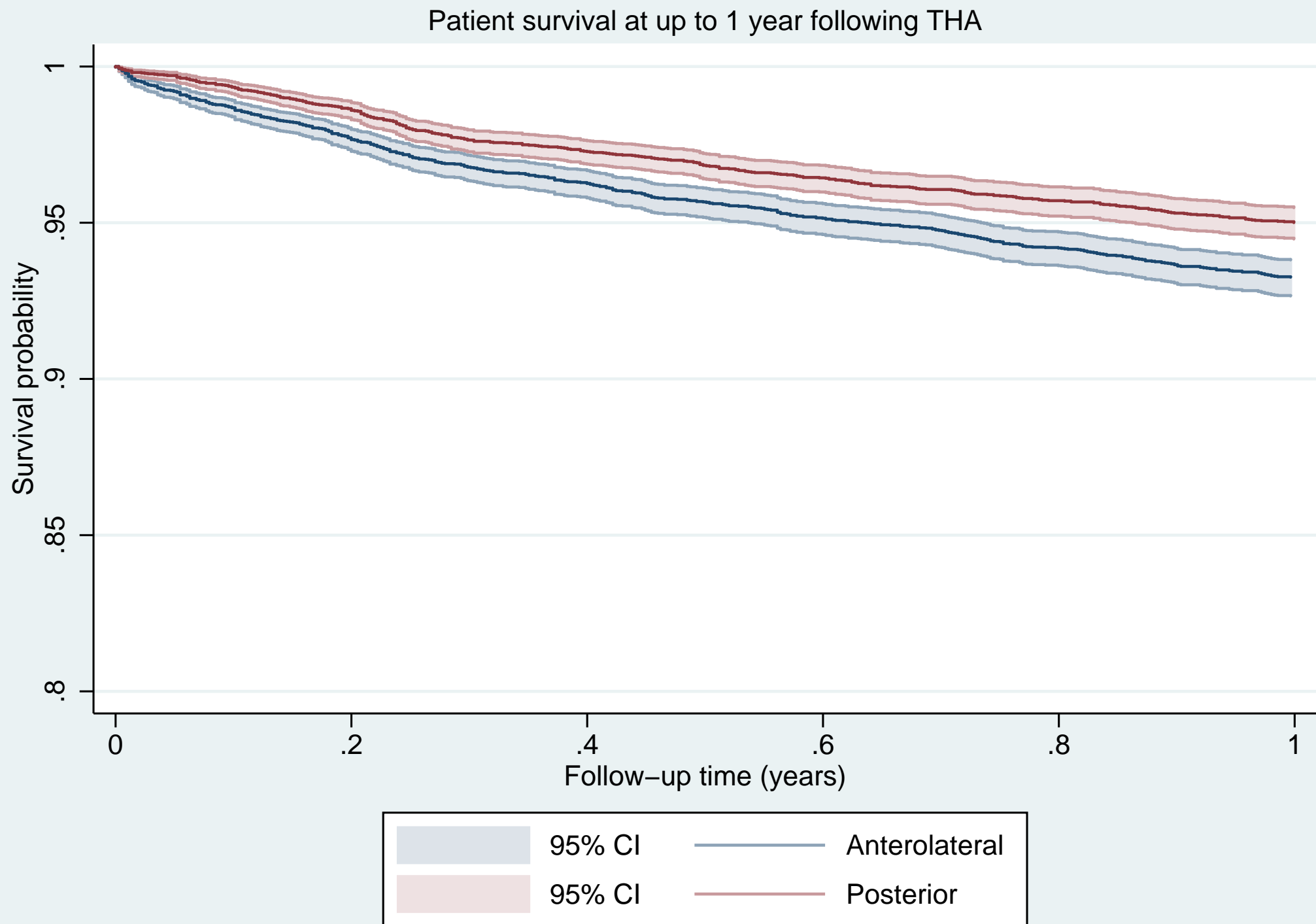


Figure 2



**Appendix Table** Outcomes following primary total hip arthroplasty performed for hip fractures by surgical approach in the unmatched cohort

	<b>Whole unmatched cohort (n=18,887; 100%)</b>	<b>Anterolateral approach (n=8,226; 43.6%)</b>	<b>Posterior approach (n=10,661; 56.4%)</b>	<b>Univariable regression analysis</b>
5 year implant survival rate free from all-causes (460 revisions)	97.2% (96.9-97.5)	97.3% (96.8-97.7)	97.1% (96.7-97.5)	SHR = 1.14 (0.95-1.37) p=0.164
5 year implant survival rate free from dislocation or subluxation (149 revisions)	99.1% (98.9-99.2)	99.1% (98.9-99.4)	99.0% (98.8-99.2)	SHR = 1.18 (0.85-1.63) p=0.326
5 year implant survival rate free from periprosthetic fracture (115 revisions)	99.3% (99.1-99.4)	99.3% (99.1-99.5)	99.2% (98.9-99.4)	SHR = 1.09 (0.75-1.58) p=0.649
30 day patient survival (174 deaths)	99.1% (99.0-99.2)	98.9% (98.6-99.1)	99.3% (99.1-99.4)	HR = 0.66 (0.49-0.88) p = 0.005

1 year patient survival (1,153 deaths)	93.9% (93.5-94.2)	93.6% (93.1-94.2)	94.1% (93.6-94.5)	HR = 0.93 (0.83-1.04)  p = 0.197
5 year patient survival (3,101 deaths)	77.2% (76.4-77.9)	77.0% (75.8-78.1)	77.3% (76.2-78.4)	HR = 0.98 (0.92-1.05)  p = 0.629
Intraoperative complications (286 complications)	1.5% (n=286)	1.9% (n=153)	1.3% (n=133)	OR = 0.67 (0.53-0.84)  p = 0.001

HR = hazard ratio; OR = odds ratio; SHR = sub-hazard ratio

Numbers in brackets represent the 95% confidence intervals.

Hazard, odds, and sub-hazard ratios below 1 represent a reduced risk of the specified outcome in the posterior approach group.

### **CME**

We were not asked to prepare these questions as per the decision letter received. Therefore we have not submitted these, but are happy to do so at the next stage or if the paper is accepted for publication.



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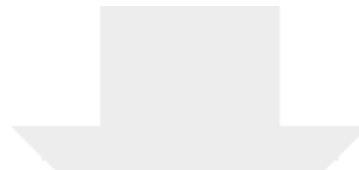
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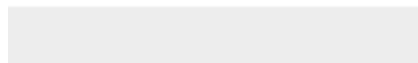
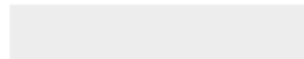


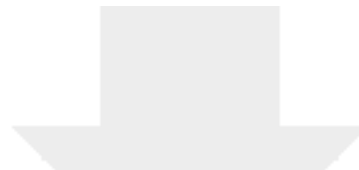


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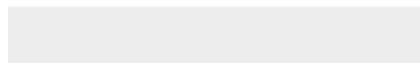
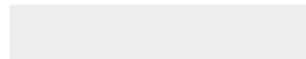
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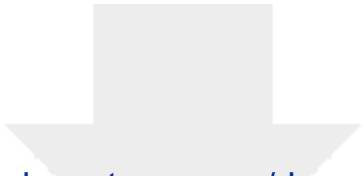




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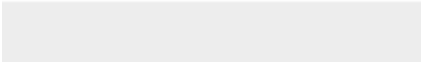
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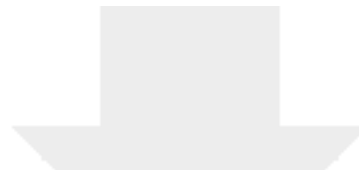


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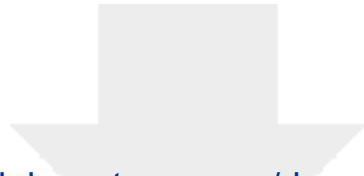




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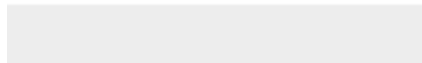
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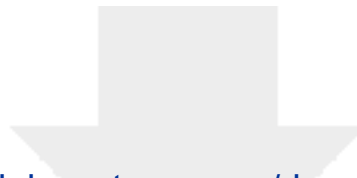




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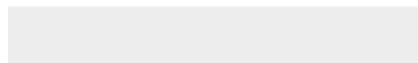
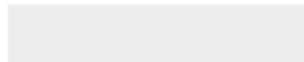




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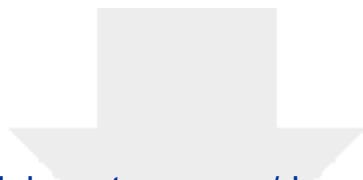
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**Statement regarding need for ethical committee approval**

The study was approved by the NJR Research Sub-Committee. As patients provide informed consent for inclusion of their data in the NJR for purposes including research, institutional review board approval was not required.



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